

Hypervelocity Expansion Tube Studies of Blunt Body Aerothermodynamics in CO₂

Completed Technology Project (2014 - 2018)



Project Introduction

According to Technology Area 09, the Entry, Descent, and Landing Roadmap, "current estimates on the extensibility of the MSL architecture indicate that it is limited to roughly 1.5 tons delivered mass, without significant investments in new technologies. Human scale mass missions, the ultimate goal in NASA's human space exploration plans, will require 20-60 tons of landed payload mass." To be capable of launching higher mass vehicles for robotic sample return and human exploration to Mars, improved accuracy in the prediction of aerodynamics and thermal loads must be made. This project will place an emphasis on Section 9.1 Aeroassist and Atmospheric Entry, specifically lower level section 1.1.6 Entry Modeling and Simulation of the TA09 roadmap. A need to produce experimental validation through ground testing is presented in the project narrative. Problematically, current state-of-the-art simulations are limited by a lack of experimental data where the free-stream thermochemical state is not well characterized. If the flow is accelerated from stagnation to hypersonic conditions through a nozzle, freezing can occur and the free stream will be partially dissociated. (Nompelis et al. 2003, 2007). The entire nozzle flow would have to be simulated and the freestream predictions of today are deemed to be inadequate. (Nompelis et al. 2010, Doraiwamy et al. 2010). To overcome this challenge, the proposed experiments will be carried out in an expansion tube facility where free stream dissociation is minimized allowing for an improved database of surface and flow field measurements at hypervelocity conditions. The Hypervelocity Expansion Tube (HET) facility at the University of Illinois at Urbana-Champaign was specifically built to eliminate the experimental challenge of freestream dissociation by accelerating the test gas through an unsteady expansion wave, rather than a nozzle. The HET has the capability of reaching a broad range of test gas conditions simply by changing the initial pressure and gas composition in the facility sections. This work has direct correlations between Space Technology Roadmaps for Entry, descent, and landing systems, specifically lower level section 1.1.6 of TABS element 9.1, because it will improve the entry modeling and simulation models for a hypersonic, chemically reacting environment. The intent to launch larger-scale vehicles requires the anomalies in the uncertainty presented in the project narrative to be resolved.

Anticipated Benefits

To be capable of launching higher mass vehicles for robotic sample return and human exploration to Mars, improved accuracy in the prediction of aerodynamics and thermal loads must be made. This project will place an emphasis on Section 9.1 Aeroassist and Atmospheric Entry, specifically lower level section 1.1.6 Entry Modeling and Simulation of the TA09 roadmap.



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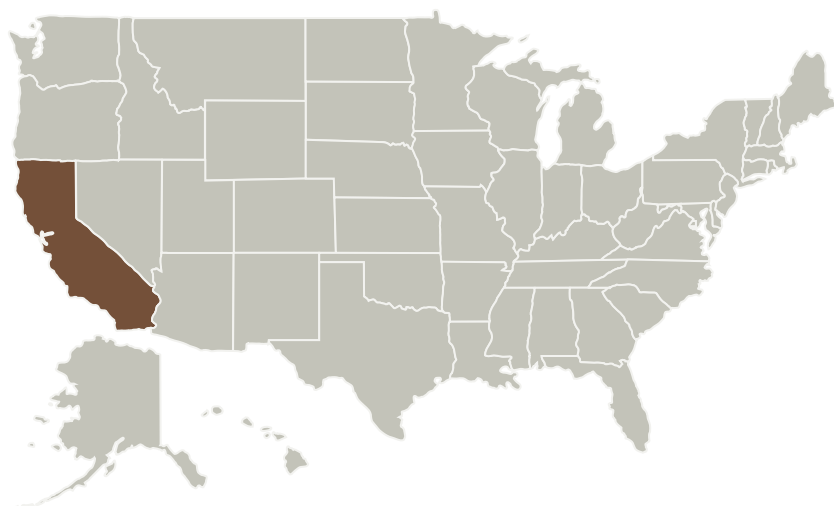
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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
California Institute of Technology (CalTech)	Lead Organization	Academia	Pasadena, California

Primary U.S. Work Locations
California

Project Website:

<https://www.nasa.gov/directorates/spacetech/home/index.html>

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

California Institute of Technology (CalTech)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Joanna Austin

Co-Investigator:

Matthew Leibowitz

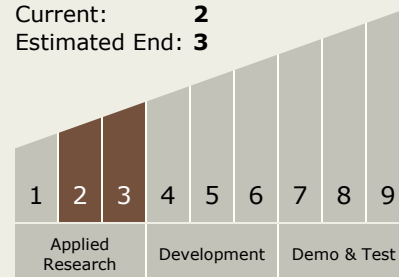
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Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX09 Entry, Descent, and Landing
 - └ TX09.4 Vehicle Systems
 - └ TX09.4.5 Modeling and Simulation for EDL

Target Destination

Foundational Knowledge